**Course Name: Systems Modeling and Simulation  
Course Code: DS331/DS24  
Problem I [Bank Multi-Channel Queue]**

**Logo

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**1\_Formulation:**

We want to study banking system to know the number of teller we need as We have two type of customers ordinary and distinguished customers The distinguished customers have a higher priority to be served waiting distinguished customer will be served before a waiting ordinary customer .and these make the waiting time for the ordinary increased.

***Objectives*.*:***

We need to keep the a higher priority for the distinguished customer and the same time reduce the waiting time for the ordinary customer

So we can gain both of them the ordinary and distinguished customer

Without any loss of them we expected that after funshing the model we can get the best solution for the ***owner of the bank*** to gain its customer

**2\_System Components:**

Entity:

* Customers [ordinary,distinguished]
* Teller

Attributies:

* Service time for the teller
* The idle for the teller
* The waiting for customer

Events:

* The arrival time for customer >> exogenous events
* The end time service[endogenous events]

State:

* Waiting for customer
* Idle for teller
* The arrival time for the next customer

**3\_System analysis:**

For Ordinary Customer:

**Cumulative distribution table for time between arrivals:**

|  |  |  |  |
| --- | --- | --- | --- |
| Time between Arrivals (Minutes) | Probabilities | Cumulative | Interval |
| 0 | 0.09 | 0.09 | 1-9 |
| 1 | 0.17 | 0.26 | 10-26 |
| 2 | 0.27 | 0.53 | 27-53 |
| 3 | 0.20 | 0.73 | 54-73 |
| 4 | 0.15 | 0.88 | 74-88 |
| 5 | 0.12 | 1.00 | 89-100 |

**Cumulative distribution table for Service Time:**

|  |  |  |  |
| --- | --- | --- | --- |
| Service Time (Minutes) | Probabilities | Cumulative | Interval |
| 1 | 0.20 | 0.20 | 1-20 |
| 2 | 0.40 | 0.60 | 21-60 |
| 3 | 0.28 | 0.88 | 61-88 |
| 4 | 0.12 | 1.00 | 89-100 |

For Distinguished Customer:

**Cumulative distribution table for time between arrivals:**

|  |  |  |  |
| --- | --- | --- | --- |
| time between arrivals | Probabilities | Cumulative | Interval |
| 1 | 0.1 | 0.10 | 1-10 |
| 2 | 0.2 | 0.30 | 11-30 |
| 3 | 0.3 | 0.60 | 31-60 |
| 4 | 0.4 | 1.00 | 61-100 |

**Cumulative distribution table for Service Time:**

|  |  |  |  |
| --- | --- | --- | --- |
| Service Time (Minutes) | Probabilities | Cumulative probabilty | Random digit assignment |
| 1 | 0.10 | 0.10 | 1-10 |
| 2 | 0.30 | 0.40 | 11-40 |
| 3 | 0.38 | 0.78 | 41-78 |
| 4 | 0.22 | 1.00 | 79-100 |

**Table for Ordinary Customer:**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| customer | Time since last arrival | Arrival time | Service time | Time service  begin | Time customer wait in system | Time service end | Time customer spend in system | Idle time of serves |
| 1 | \_-- | 0 | 2 | 2 | 2 | 4 | 2 | 0 |
| 2 | 2 | 2 | 2 | 7 | 5 | 9 | 2 | 0 |
| 3 | 0 | 2 | 1 | 33 | 31 | 34 | 1 | 0 |
| 4 | 5 | 7 | 4 | 34 | 27 | 38 | 4 | 0 |
| 5 | 4 | 11 | 3 | 38 | 27 | 41 | 3 | 0 |
| 6 | 1 | 12 | 1 | 41 | 29 | 42 | 1 | 0 |
| 7 | 1 | 13 | 1 | 42 | 29 | 43 | 1 | 0 |
| 8 | 4 | 17 | 3 | 43 | 26 | 46 | 3 | 0 |
| 9 | 3 | 20 | 2 | 46 | 26 | 48 | 2 | 0 |
| 10 | 3 | 23 | 2 | 48 | 25 | 50 | 2 | 0 |
|  |  |  | 21 |  | 227 |  | 21 | 0 |

**Table for Distinguished Customer:**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| customer | Time since last arrival | Arrival time | Service time | Time service  begin | Time customer wait in system | Time service end | Time customer spend in system | Idle time of serves |
| 1 | \_-- | 0 | 2 | 0 | 0 | 2 | 2 | 0 |
| 2 | 4 | 4 | 3 | 4 | 0 | 7 | 3 | 0 |
| 3 | 4 | 8 | 4 | 9 | 1 | 13 | 4 | 0 |
| 4 | 4 | 12 | 4 | 13 | 1 | 17 | 4 | 0 |
| 5 | 2 | 14 | 2 | 17 | 3 | 19 | 2 | 0 |
| 6 | 3 | 17 | 3 | 19 | 2 | 22 | 3 | 0 |
| 7 | 3 | 20 | 3 | 22 | 2 | 25 | 3 | 0 |
| 8 | 3 | 23 | 3 | 25 | 2 | 28 | 3 | 0 |
| 9 | 2 | 25 | 2 | 28 | 3 | 30 | 2 | 0 |
| 10 | 4 | 29 | 3 | 30 | 1 | 33 | 3 | 0 |
|  |  |  | 29 |  | 15 |  | 29 | 0 |

4\_Experimental design Parameters:

We run the program for 10 times for both type of customer and see the result for waiting time for both

And we noted that the waiting time is increased for ordinary because the higher priority for the distinguished customer

\_\_\_\_\_\_\_\_\_\_\_\_\_

**6\_Results Analysis: Using graphs & discussions stating the results for the 8 questions**

\_The average service time of the teller= (service time of all ordinary customers+ service time of all Distinguished Customer)/(number of ordinary+ number of Distinguished )=(29+21)/(10+10)=2.5

\_ The average waiting time of ordinary customers=sum of waiting time/number of them=227/10=22.7Chart, histogram

Description automatically generated

\_ The average waiting time of Distinguished customers= sum of waiting time/number of them=15/10=1.5

Chart, bar chart

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\_ The maximum for ordinary =10

\_the maximum for distinguished =8

\_ The probability that an ordinary customer and a distinguished customer wait in the queue= (number of ordinary customers who have waiting time + number of distinguished customers who have waiting time )/(number of ordinary+ number of Distinguished )=(10+8)/(10+10)=0.9

\_ The probability that an ordinary customer wait =10/10=1

\_ The probability that an distinguish customer wait=8/10=0.8

\_The portion of idle time of the teller for the ordinary= 0.

\_The portion of idle time of the teller for the distinguished=0

\_ the theoretical average service=2.5

The average service time for ordinary=21/10=2.1(approximately match with the theoretical average service)

The average service time for distinguish=2.9(approximately match with the theoretical average service)

\_theoretical average inter-arrival time for ordinary=2.5

The average inter-arrival time for ordinary=2.3(approximately match with theoretical average inter-arrival time)

theoretical average inter-arrival time for distinguished=2.5

The average inter-arrival time for distinguish=2.9(approximately match with theoretical average inter-arrival time)

\_If we add teller to serve the distinguished customers only:

**The table of ordinary customers will update to:**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| customer | Time since last arrival | Arrival time | Service time | Time service  begin | Time customer wait in system | Time service end | Time customer spend in system | Idle time of serves |
| 1 | \_ | 0 | 2 | 0 | 0 | 2 | 2 | 0 |
| 2 | 2 | 2 | 2 | 2 | 0 | 4 | 2 | 0 |
| 3 | 0 | 2 | 1 | 4 | 2 | 5 | 1 | 0 |
| 4 | 5 | 7 | 4 | 7 | 0 | 11 | 4 | 2 |
| 5 | 4 | 11 | 3 | 12 | 0 | 14 | 3 | 0 |
| 6 | 1 | 12 | 1 | 14 | 2 | 15 | 1 | 0 |
| 7 | 1 | 13 | 1 | 15 | 2 | 16 | 1 | 0 |
| 8 | 4 | 17 | 3 | 17 | 0 | 20 | 3 | 1 |
| 9 | 3 | 20 | 2 | 20 | 0 | 22 | 2 | 0 |
| 10 | 3 | 23 | 2 | 23 | 0 | 25 | 2 | 1 |
|  |  |  | 21 |  | 6 |  | 21 | 4 |

\_ The average waiting time of ordinary customers will be =6/10=0.6

Chart, histogram

Description automatically generated

\_ The maximum for ordinary will be 2m

\_ The probability that an ordinary customer wait=3/10=0.3

**The table of distinguished customers will update to:**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| customer | Time since last arrival | Arrival time | Service time | Time service  begin | Time customer wait in system | Time service end | Time customer spend in system | Idle time of serves |
| 1 | \_ | 0 | 2 | 0 | 0 | 2 | 2 | 0 |
| 2 | 4 | 4 | 3 | 4 | 0 | 7 | 3 | 2 |
| 3 | 4 | 8 | 4 | 8 | 0 | 12 | 4 | 1 |
| 4 | 4 | 12 | 4 | 12 | 0 | 16 | 4 | 0 |
| 5 | 2 | 14 | 2 | 16 | 2 | 18 | 2 | 0 |
| 6 | 3 | 17 | 3 | 18 | 1 | 21 | 3 | 0 |
| 7 | 3 | 20 | 3 | 21 | 1 | 24 | 3 | 0 |
| 8 | 3 | 23 | 3 | 24 | 1 | 27 | 3 | 0 |
| 9 | 2 | 25 | 2 | 27 | 2 | 29 | 2 | 0 |
| 10 | 4 | 29 | 3 | 29 | 0 | 32 | 3 | 0 |
|  |  |  | 29 |  | 7 |  | 29 | 3 |

\_ The average waiting time of distinguish customers will be =7/10=0.7

Chart, histogram

Description automatically generated

\_ The maximum for distinguish will be 2m

\_ The probability that an ordinary customer wait=5/10=0.5

\_The probability that an ordinary customer and a distinguished customer wait in the queue=8/20=0.4

**7\_ Conclusion:**

The average waiting time of ordinary customers will update from 22.7 to 0.6

The average waiting time of distinguish customers will update from 1.5 to 0.5

By adding the teller

\_ the rules we use on it:

Number of customers is given by user.

\_Time since last arrival and service time is generated randomly.

\_Arrival time = Time since last arrival of customer before + Time since last arrival of the customer.

For first customer :

\_Time service begin=0

\_time service end=service time +time service begin

\_time customer wait=0

\_ time customer spend in system=time service end-arrival time

\_ idle time of server=0

For other customers:

If arrival time of customer is less than service end time of customer before :

\_ time service begin= service end time of customer before

\_time service end =service time +time service begin.

\_time customer wait=time service begin- arrival time

\_time customer spend in system= time service end-time service begin.

\_idle time of server=time service begin-time service end of customer before.